

“Messy” Tropical Storm Isaac Sweeps through Caribbean Sea, South of Puerto Rico and USVI

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a. Synoptic History

In the middle of the third week of August a strong tropical wave left Africa on its voyage across the Atlantic Ocean. The GFS model was very persistent in developing this wave into a significant cyclone as it crossed the Atlantic. But satellite images indicated that development was slow, the system lacked organized convection, and had a region of Saharan layer just to its north in the boundary layer including a large area of dust.

On August 21st the convection had developed enough so the National Hurricane Center began issuing advisories on it as Tropical Depression Nine. The initial advisory at 500 am AST mentioned that the center was at 15.2°N and 51.2°W with maximum sustained winds of 35 mph, moving west at 20 mph. It was forecasted to reach hurricane strength within 48 hours, when it would be about 120 nm (222 km) southeast of St. Croix, U.S. Virgin Islands (Fig.1) late on Wednesday night. Tropical storm warnings were issued for much of the Northern Lesser Antilles while a tropical storm watch was issued for Puerto Rico and the U.S. Virgin Islands.

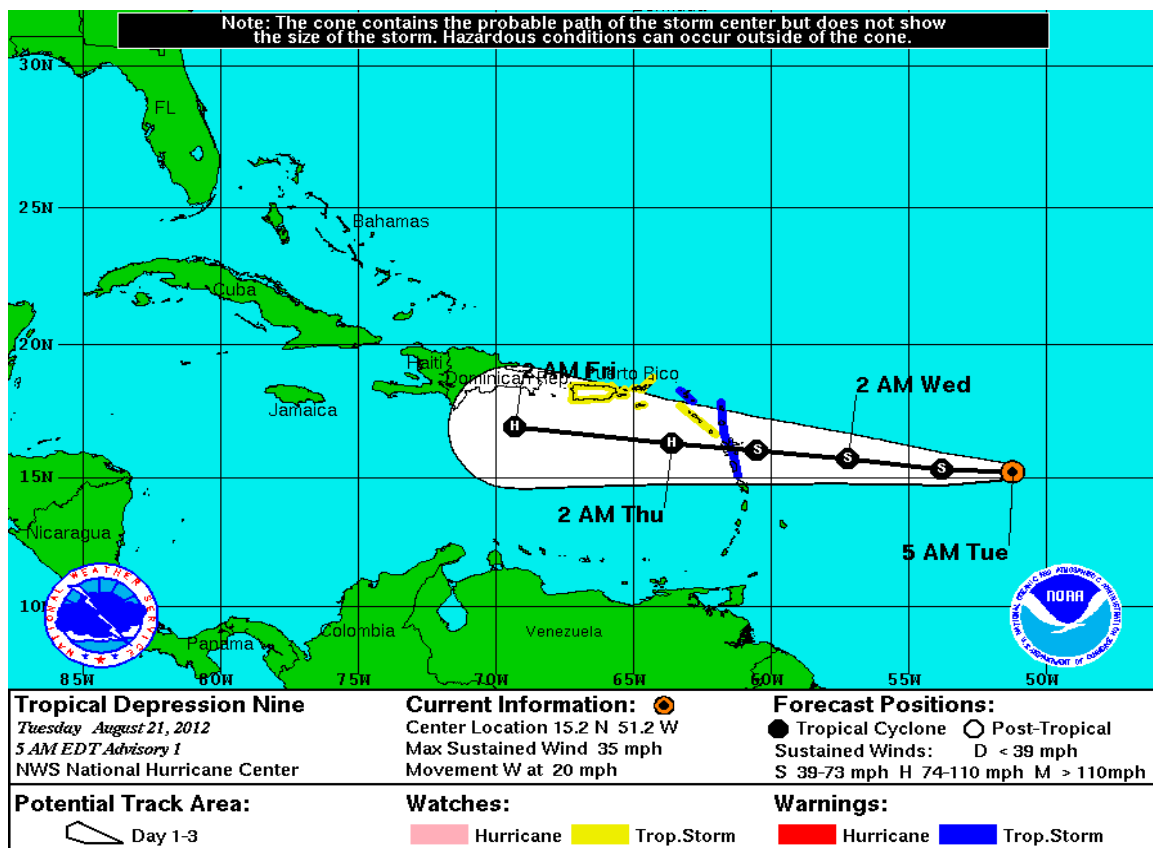


Fig. 1. Initial forecast of Tropical Depression Nine.

It was not obvious that dry air on the north and west sides of the depression would have a major impact on its development (Fig. 2), and in hindsight this was probably a much underestimated factor. Modest vertical wind shear during the depression stage was the only factor at the time thought to prevent it from becoming a hurricane very soon after arriving into the Caribbean Sea. However, a very large Saharan Dust Layer surrounded the tropical depression as the visual satellite image shows at the same time (Fig. 3), wrapping around the north and west sides of the depression and possibly even into the southwest and into the core. Nonetheless the convection was increasing and further development seemed likely.

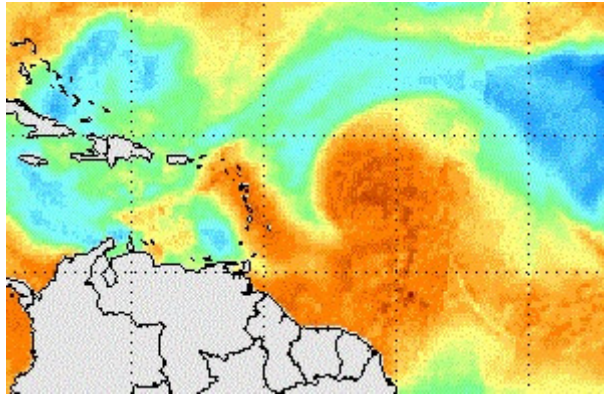


Fig. 2. Total precipitable water as shown on MIMIC/TPW product on 500 am AST August 21 (0900 UTC).

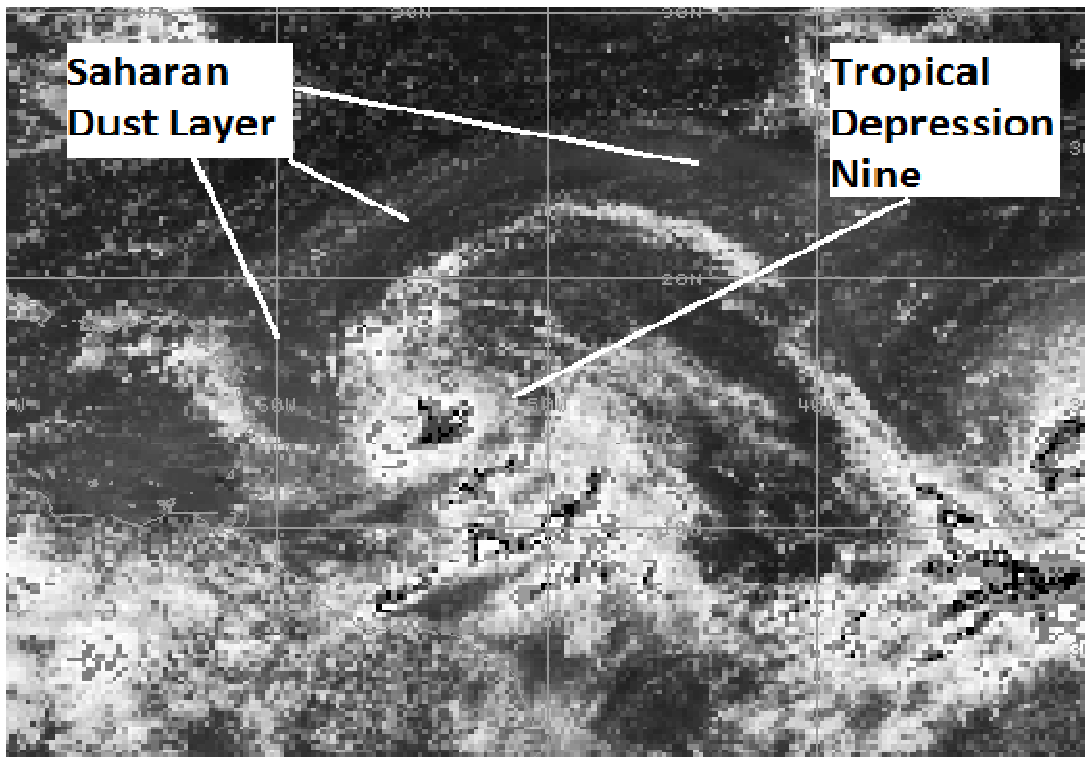


Fig. 3. Visual satellite view of tropical depression nine at 500 am AST, August 21.

Within 6 hours after the first advisory the Oceansat-2 scatterometer (OSCAT) showed a closed circulation (Fig. 4). The black colored winds on the southwest and south sides of the low center indicates possible contaminated data but strongest winds are shown well north of the center.

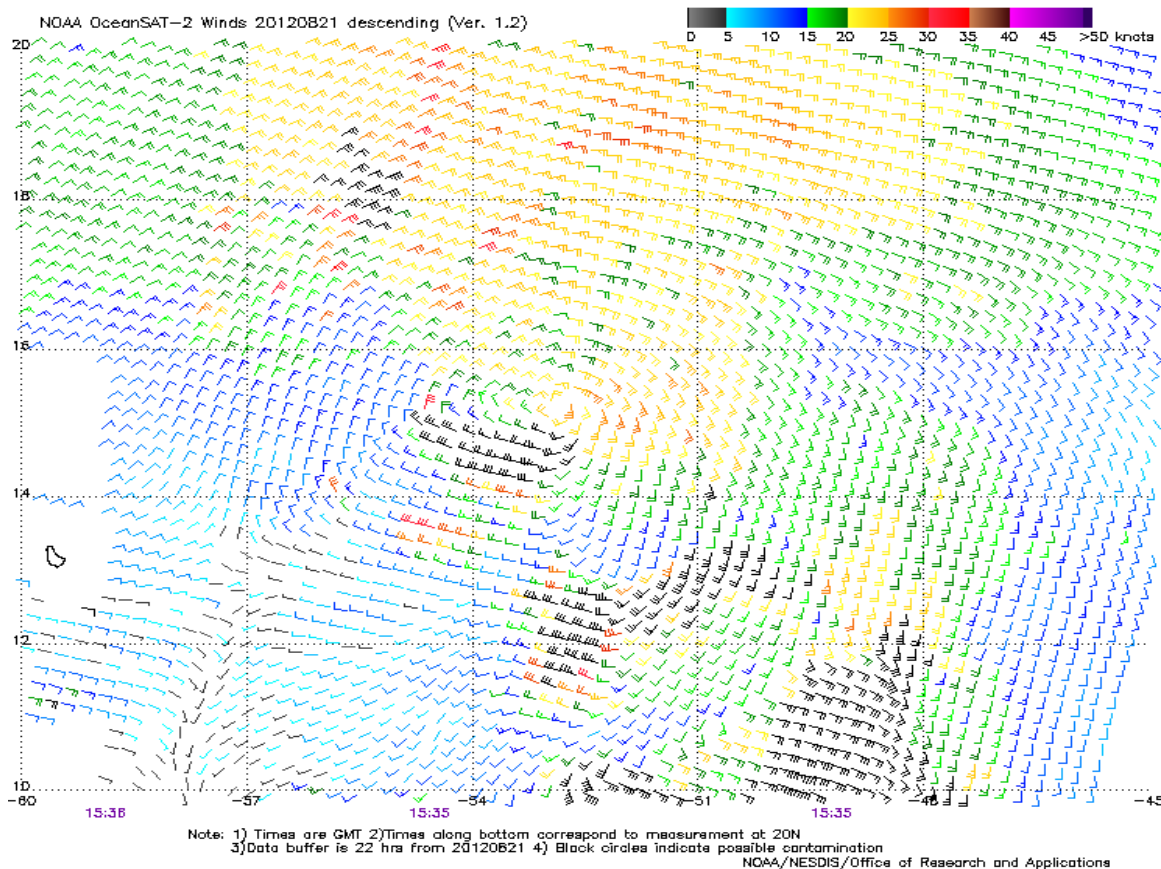


Fig. 4. Descending pass of OSCAT (NOAA Oceansat-2 Scatterometer) on August 21 showing a very large area of 20 to 25 knots (some to 30) of wind on the north side of the low center.

A Hurricane Hunter aircraft flew through the developing system during the day and found 44 knots of wind only 1000 feet off of the ocean surface, and a central pressure of 1005 mb. The depression was then upgraded to Tropical Storm Isaac at 500 pm AST, August 21. No significant changes were noted by 1100 pm on August 21 and there was much uncertainty noted in discussions regarding with Isaac. A hurricane watch was issued for the possibility of such conditions for the U. S. Virgin Islands, Puerto Rico, Vieques, and Culebra.

Early during the formation of Isaac the National Hurricane Center discussions mentioned a couple of factors that kept this developing cyclone from developing significantly over its first 48 hours, including light to moderate northeasterly shear, and that the wind field and convection were disorganized, caused in part by dry air entrainment into the circulation. Even so, the threat of widespread and intense heavy rain in showers and

thunderstorms for Puerto Rico and the U.S. Virgin Islands was high as Isaac would soon be in the vicinity. A flash flood watch was issued for all of the local islands at 1000 am AST August 22 (Wed.), in effect beginning that evening and valid through Saturday morning, the 25th. The dry air on the north side of the cyclone indicated that rainfall might initially be less than the forecast average of 3 inches for the balance of Wednesday and into Thursday, but then total amounts could increase to 4 to 6 inches by the end of the week.

The atmospheric sounding taken on the northern periphery of the low at 800 pm August 22 (Fig. 4) showed the dry air above 850 mb, and especially above 700 mb. By 1100 pm the hurricane watch had been discontinued for the U.S. Virgin Islands, Puerto Rico, Vieques and Culebra, however the tropical storm warning continued. Isaac began to be described at various times in the forecast office as “messy,” meaning that it was disorganized and difficult to forecast.

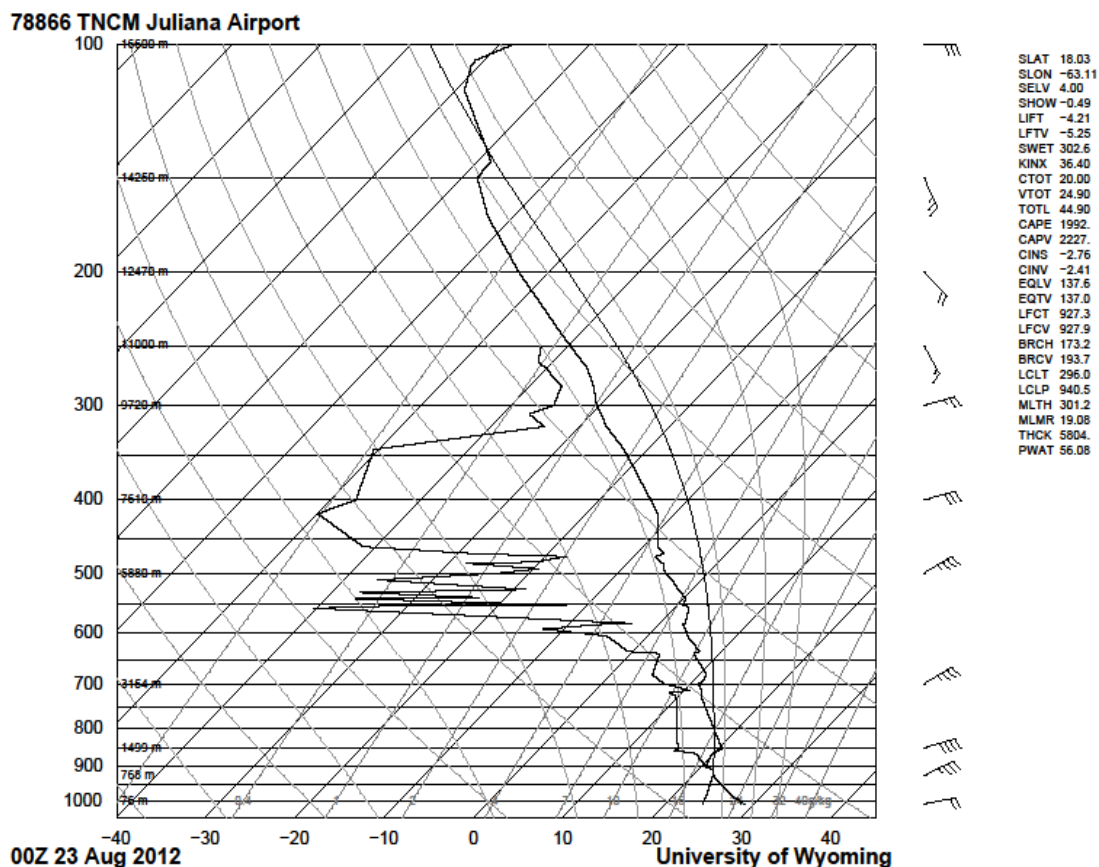


Fig. 4. Sounding from Juliana Airport (TNCM), St. Maarten at 800 pm August 22.

Early on Thursday August 23rd, deep convection had developed well southwest of where the poorly defined center was thought to be. Reconnaissance aircraft, radars from San Juan and Guadeloupe, and a buoy in the eastern Caribbean led to a relocation of the elongated center towards the southwest and its forecast track remained uncertain. The

early morning OSCAT image (Fig. 5) showed rather weak winds close to the center west of Dominica though these winds are usually less reliable on OSCAT at the edge of a scan. Much stronger winds were indicated towards the northeast indicating its broad

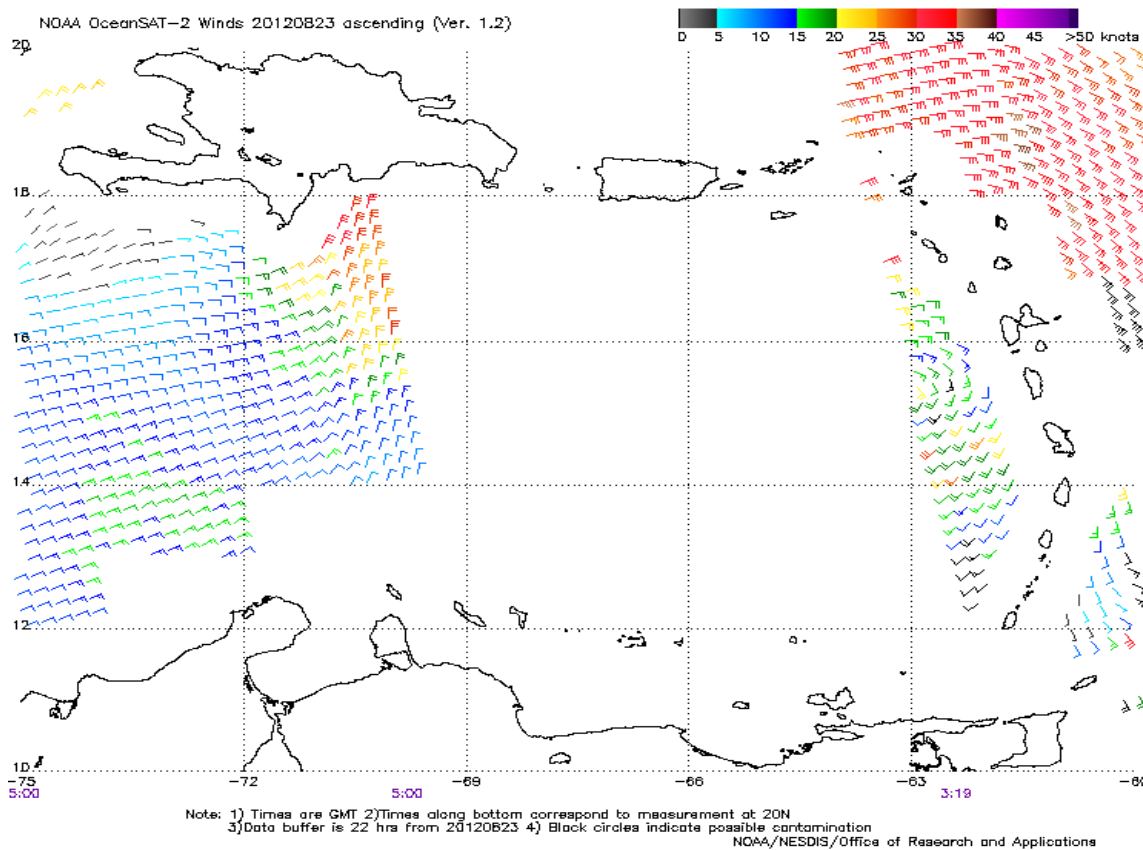


Fig. 5. Ascending image from OSCAT early on August 23.

circulation. Even though it was still a minimal tropical storm with maximum sustained winds of 40 mph the storm force winds extended up to 120 nm towards the northeast of center. Figure 6 shows the relocated center of Isaac by 1100 AST, still with most convection towards the southwest of the center. The new forecast track (Fig. 7) was farther from the local islands but with the storm force winds extending so far northeast of the center it appeared that this could be a major threat on the following day.

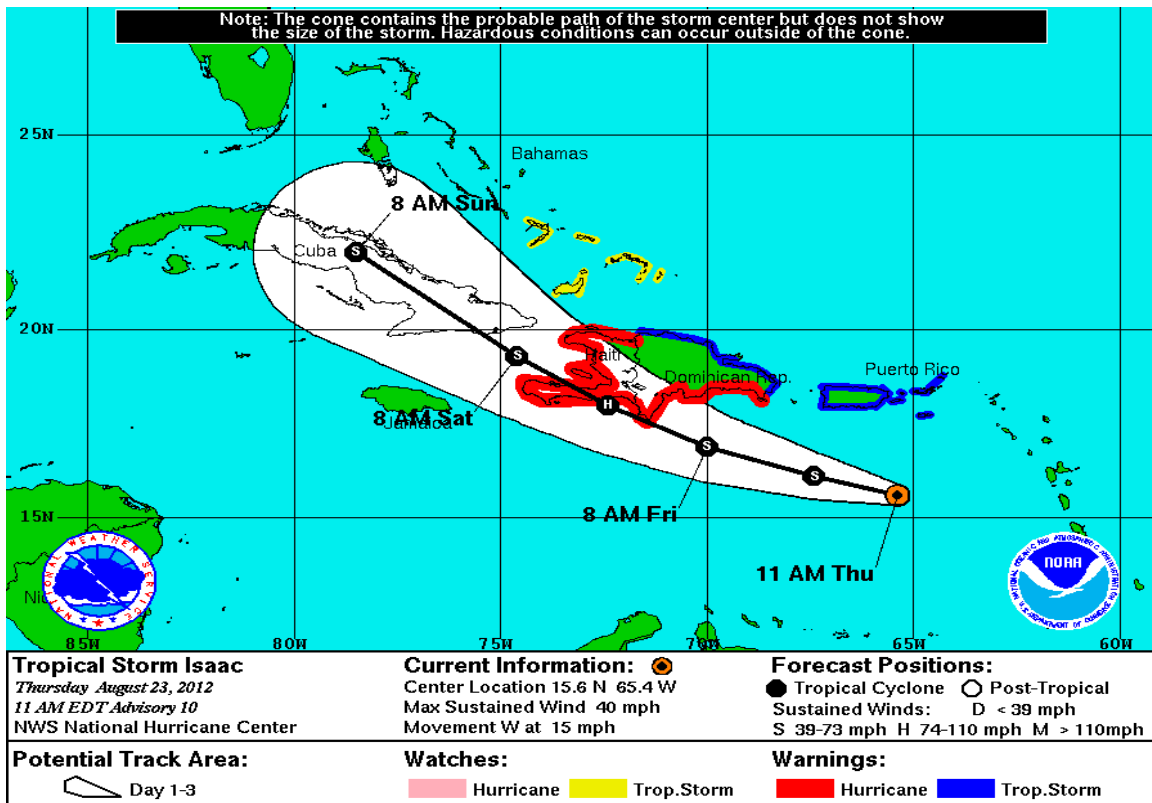


Fig. 6. Tropical Storm Isaac forecast track from 1100 am AST, August 23.

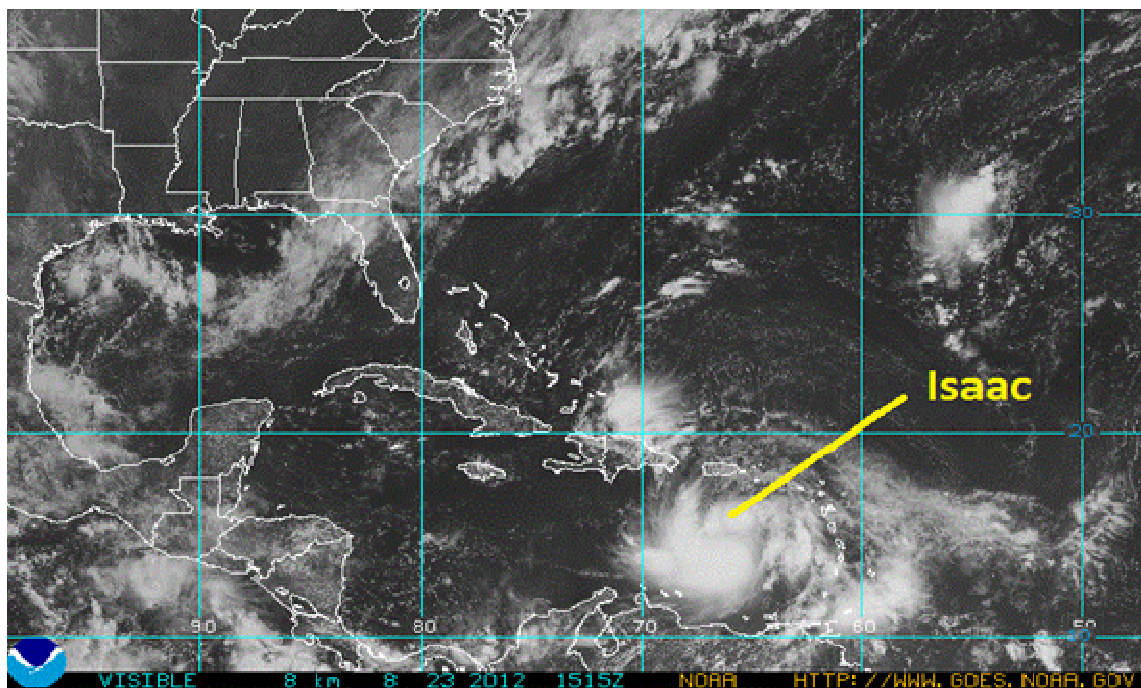


Fig. 7. Visual satellite picture of Tropical Storm Isaac at 1115 am AST, August 23, with the center noted on the image.

The tropical storm warnings for Puerto Rico, Vieques, Culebra, and the U.S. Virgin Islands was discontinued at 1100 pm AST on August 23rd as the center of Isaac had reached the waters south of the Dominican Republic.

b. Rainfall

Although convective rainfall occurred during the 24 hours ending on Thursday, the 23rd (Table 1), it was not enough to cause significant flooding. The atmospheric sounding at San Juan, PR, taken at 800 pm August 22nd (Fig. 8) showed 2.41 inches of precipitable water, normally enough to be of concern for flooding rains. However, the middle to upper portion of the troposphere was far from saturation as it is in most tropical cyclones with a heavy rain threat. This was the highest value of precipitable water that would be recorded on the San Juan soundings during the passing of Isaac.

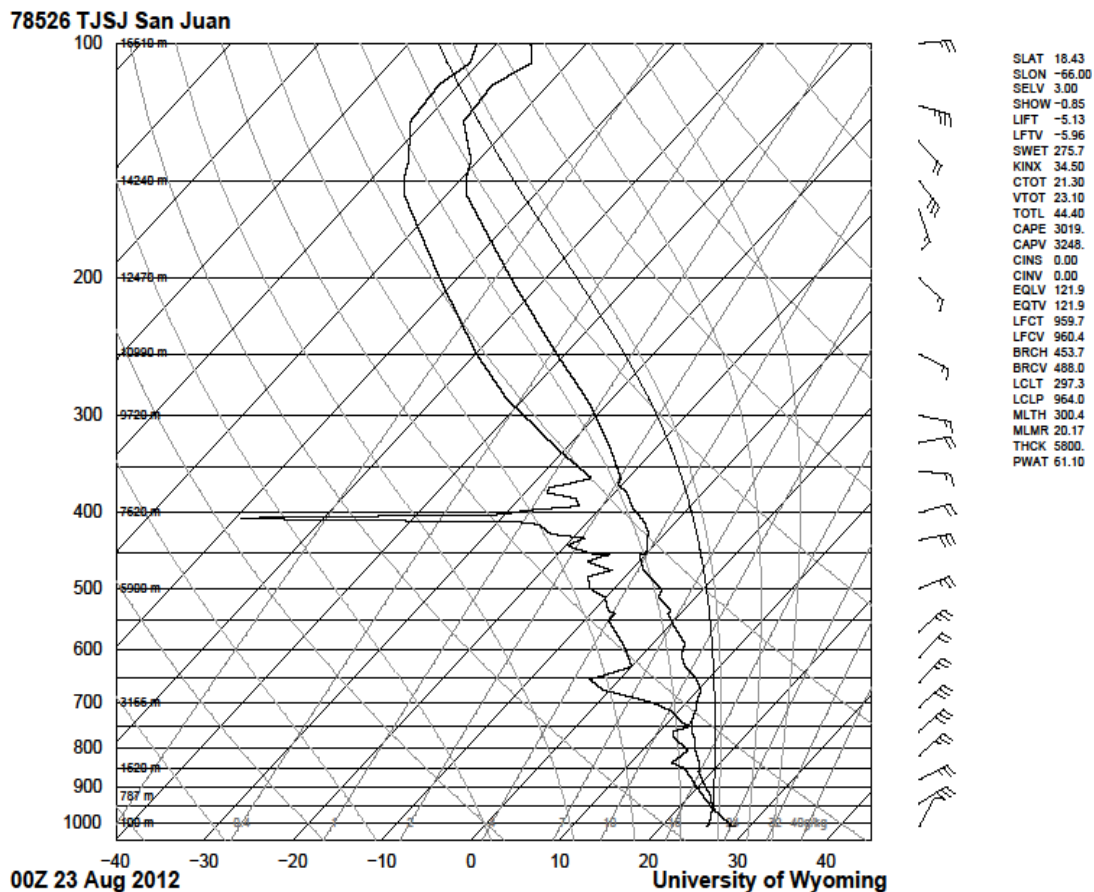


Fig. 8. Sounding from San Juan, PR (TJSJ) at 800 pm August 22.

The amount of precipitable water above San Juan had fallen off to 2.29 inches by early on August 23rd (Fig. 9) and was showing even drier air above 771 mb (7 kft). But sustained winds had increased to 48 knots (55 mph) at only 2000 feet above ground. There was potential for much of this wind to mix down to the surface, but it was even

more likely that developing convection would have strong potential to cause wind gusts this high or higher.

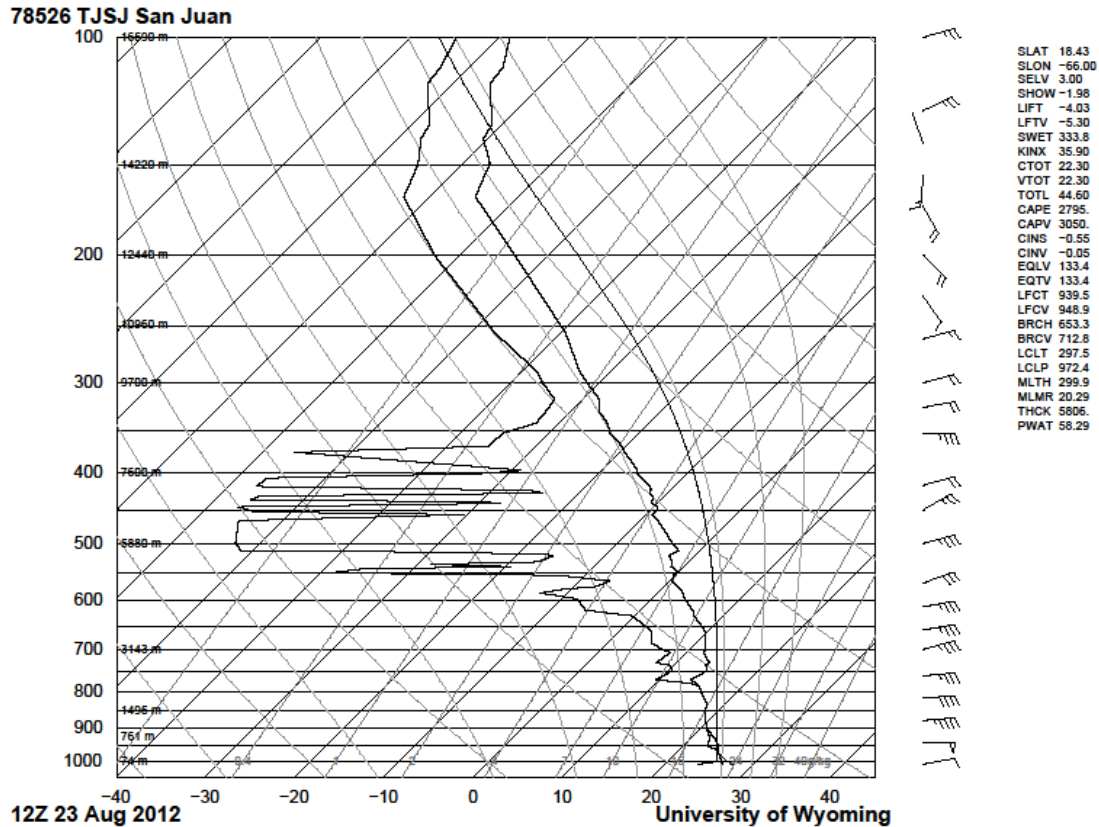


Fig. 9. Sounding from San Juan, PR (TJSJ) at 800 am August 23.

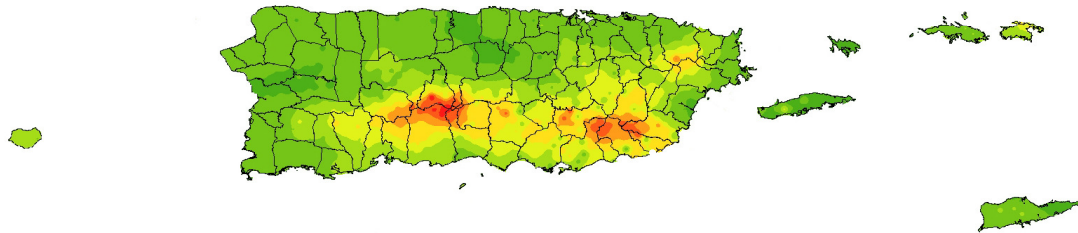
Heavy rain did occur during the 48 hours between 800 am on the 23rd to 800 am on the 25th (Table 1) once Isaac had moved southwest of Puerto Rico. However, it was not widespread and only 6 flash flood warnings were issued that covered 23 municipalities. Four of the warnings verified with flash flooding water and mudslides in Penuelas, Sabana Grande, Juana Diaz, Guyanilla, Ponce, Maunabo, Patillas, San Lorenzo, Cayey, and Utuado. Figure 10 is a GIS produced image of the rainfall distribution for the 3 days ending at 800 am August 26.

Location ID	Location Description	Date, 24 Hour Rainfall amount (in.) ending at 800 am AST				
		23	24	25	26	4-Day Total
JAMP4	Boca Collores near Jayuya	0.29	4.52	3.58	0.00	8.39
PARP4	Boca Marin near Patillas	0.32	1.60	4.39	0.23	6.54
NGIP4	Rio Icacos near Naguabo	0.85	1.97	1.42	2.17	6.41
IANP4	Rio Inabon at Real Abajo	0.01	2.74	2.73	0.00	5.48
PATP4	Rio Grande de Patillas near Patillas	0.07	1.30	3.75	0.35	5.47
ZEDP4	Rio la Plata-Cidra	0.63	1.93	2.01	0.24	4.81
LLUP4	Lago Luchetti at damsite near Yauco	0.01	2.74	1.86	0.01	4.62
YBUP4	Rio Guayanes near Yabucoa	0.37	0.87	3.24	0.11	4.59
SLKP4	Rio Cayaguas at Cerro Gordo	0.49	0.84	2.91	0.29	4.53
PRTP4	Rio Portugues near Tibes	0.01	2.61	1.88	0.00	4.50
PASP4	Lago Patillas near Patillas	0.11	0.92	3.28	0.15	4.46
GUSP4	Pueblito del Rio las Piedras	0.85	1.64	1.08	0.83	4.40
PCXP4	Lago Cerrillos near Ponce	0.01	2.20	2.18	0.00	4.39
LICP4	Lago Icacos at damsite	0.74	0.97	0.98	1.69	4.38
ZECP4	Cayey	0.31	1.38	2.60	0.08	4.37
VINP4	Barrio Apeadero near Villalba	0.50	1.50	2.36	0.01	4.37
SLNP4	Rio Grande de Loiza San Lorenzo	0.20	0.78	2.82	0.41	4.22
BZCP4	Vaqueria el Mimo Caguas	0.33	1.48	2.37	0.01	4.19

Table 1. Rain gages that reported more than 4 inches during the 4 days ending on August 26, 2012. All of them are in the south-central or southeast portions of Puerto Rico, where upslope flow and south to southeast winds in outer rain bands from Isaac contributed to heavy rain.



ISAAC RAIN TOTALS 0823/12z to 0826/12Z



0 5 10 20 30 40 Miles

Source: AHPS
Data Points: 818
Maximum: 7.92 inches
Minimum: 0.22
Mean: 2.40

Isaac Rain

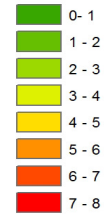


Fig. 10. Rainfall during the period from 800 am AST August 23 to 800 am August 26, focusing most on the south and southeast slopes of Puerto Rico mountains.

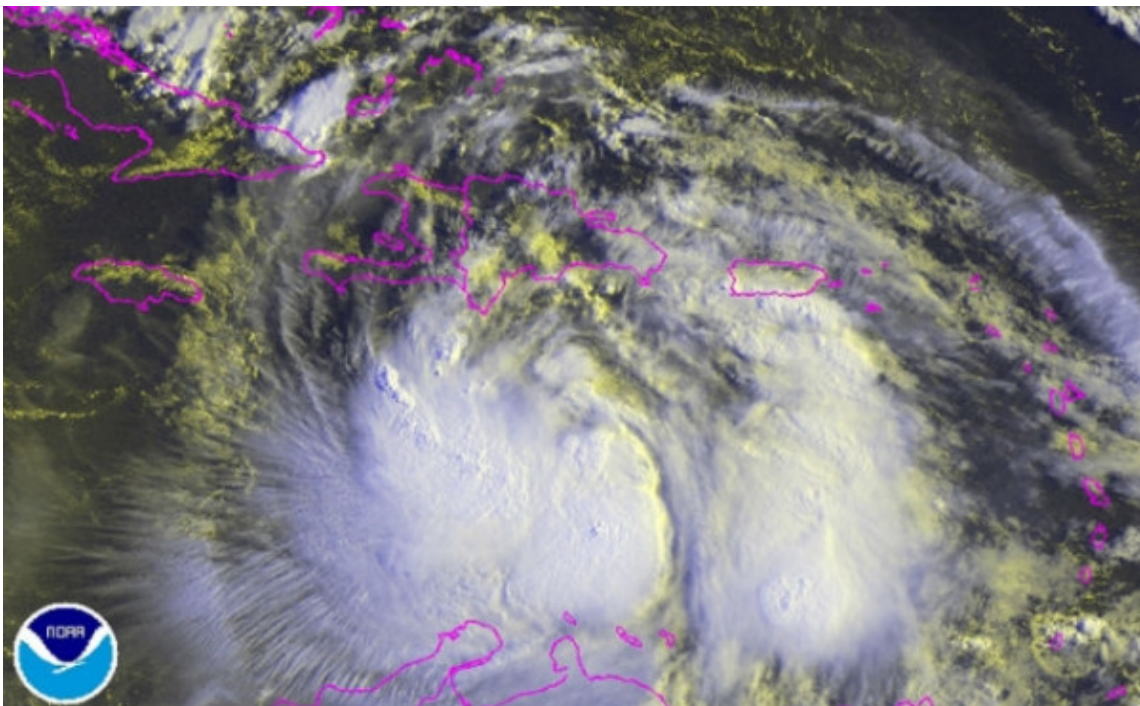


Fig. 11. Visual satellite image of Isaac at 745 am AST August 24. The center of Isaac is passing south of Hispanola in this image while the outer rain bands approach the south coast of Puerto Rico.

c. Damage and Other Impacts, Watches and Warnings

Damage from Isaac was relatively minor. Power outages were reported across several sectors in Saint Croix, plus Guaynabo, Bayamon, San Juan, Arecibo, Caguas, Mayaguez, and Maricao. Coastal flooding closed a road between Naguabo and Punta Santiago. All significant flooding was reported to have occurred between 300 pm on Aug. 23rd and 300 pm on Aug. 24th.

There were 8 special marine warnings issued for intense thunderstorms or tropical rain bands passing through regional waters, with locally higher wind and seas that were expected in the area though these conditions are mostly unverifiable. Figure 12 shows the wind and seas that occurred at buoy 41052, south of Saint John during August 22 – 24, with wind gusts reaching 45 mph and wave heights reaching 12.5 feet on the afternoon of the 23rd. These peaks in the wind and seas were not associated with thunderstorms or rain bands, but these conditions were typical for the area at the time. The coastal waters forecast in effect at the time from the San Juan forecast office called for winds 30 to 35 knots and seas at 10 to 14 feet.

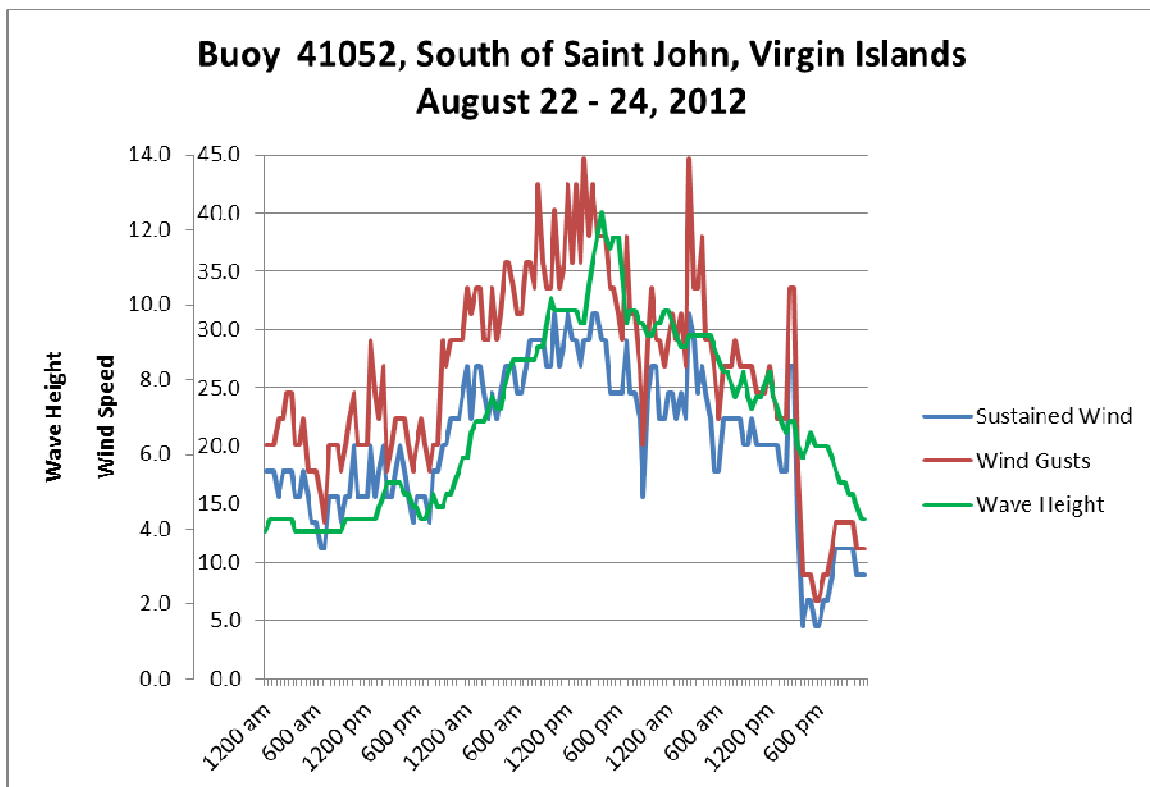


Fig. 12. Buoy 41052, showing winds and waves for August 22-24.

Figure 13 shows the dates/times for the watches and warnings that were issued and were associated with Isaac.

Type of Issuance	Location	Date/Time (AST)
Tropical Storm Watch	Puerto Rico, Vieques, Culebra, U.S. Virgin Islands	21 st /500 am
Tropical Storm Warning and Hurricane Watch	U.S. Virgin Islands, Puerto Rico, Vieques, Culebra	21 st /1100 pm
Flash Flood Watch	U.S. Virgin Islands, Puerto Rico, Vieques, Culebra	22 nd /1000 am
Hurricane Watch Ended	U.S. Virgin Islands, Puerto Rico, Vieques, Culebra	22 nd /1100 pm
Tropical Storm Warning Ended	Puerto Rico, Vieques, Culebra, U.S. Virgin Islands	23 rd /1100 pm
6 Flash Flood Warnings	Numerous municipalities	23 rd – 24 th
8 Special Marine Warnings	Coastal Waters	23 rd – 24 th

Fig. 13. Watches and warnings associated with Isaac, issued by San Juan Weather Forecast Office.

d. Conclusion

Isaac was a weak tropical storm when it passed south of Puerto Rico and the U. S. Virgin Islands on August 23rd, and the storm center was often difficult to locate. Very difficult for the National Hurricane Center and the San Juan office to forecast in its track, its intensity, and how much potential it had for flooding rains, caution was largely the message in that more watches were issued for long periods than were the short duration warnings. Short term forecasts (less than a day) were much better than longer period forecasts which involved much greater uncertainty.

Dry air on the north side of Isaac, largely a Saharan Dust Layer, was a significant factor in not only flooding rains being delayed beyond August 22nd, but the amount of rain that finally did occur on the 23rd and 24th was less than expected. The dust layer also very likely reduced the intensification of the storm by reducing convection in Isaac's core. The dust affected the storm development for its entire journey across the Atlantic, continued to do so once reaching the Caribbean Sea, and, did so as the storm reached an otherwise favorable region to develop into a much more significant tropical cyclone.